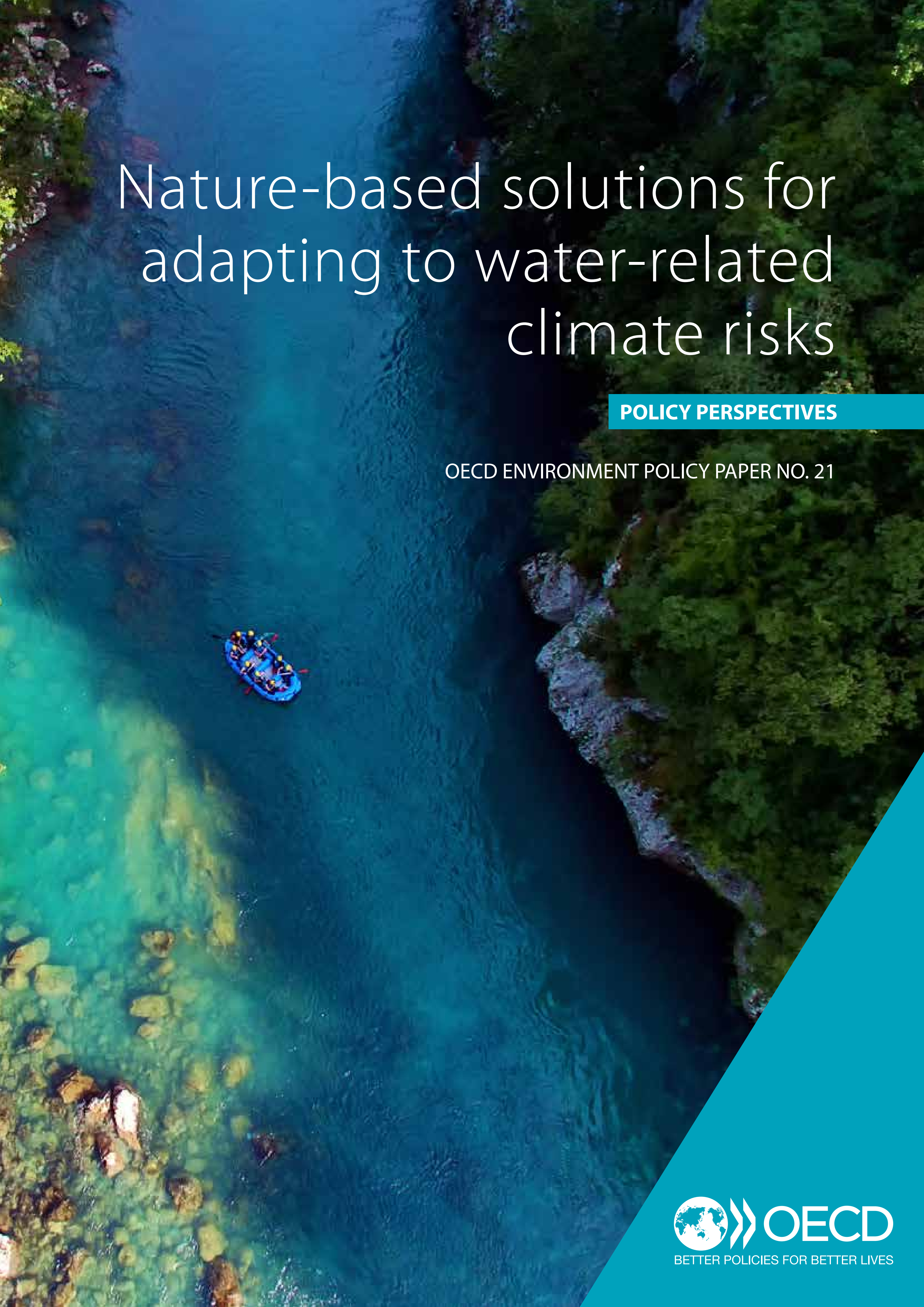

Nature-based solutions for adapting to water-related climate risks

POLICY PERSPECTIVES

OECD ENVIRONMENT POLICY PAPER NO. 21

OECD
BETTER POLICIES FOR BETTER LIVES

While significant government resources need to address the social and economic consequences of the COVID-19 crisis, climate change and biodiversity loss remain urgent global challenges.

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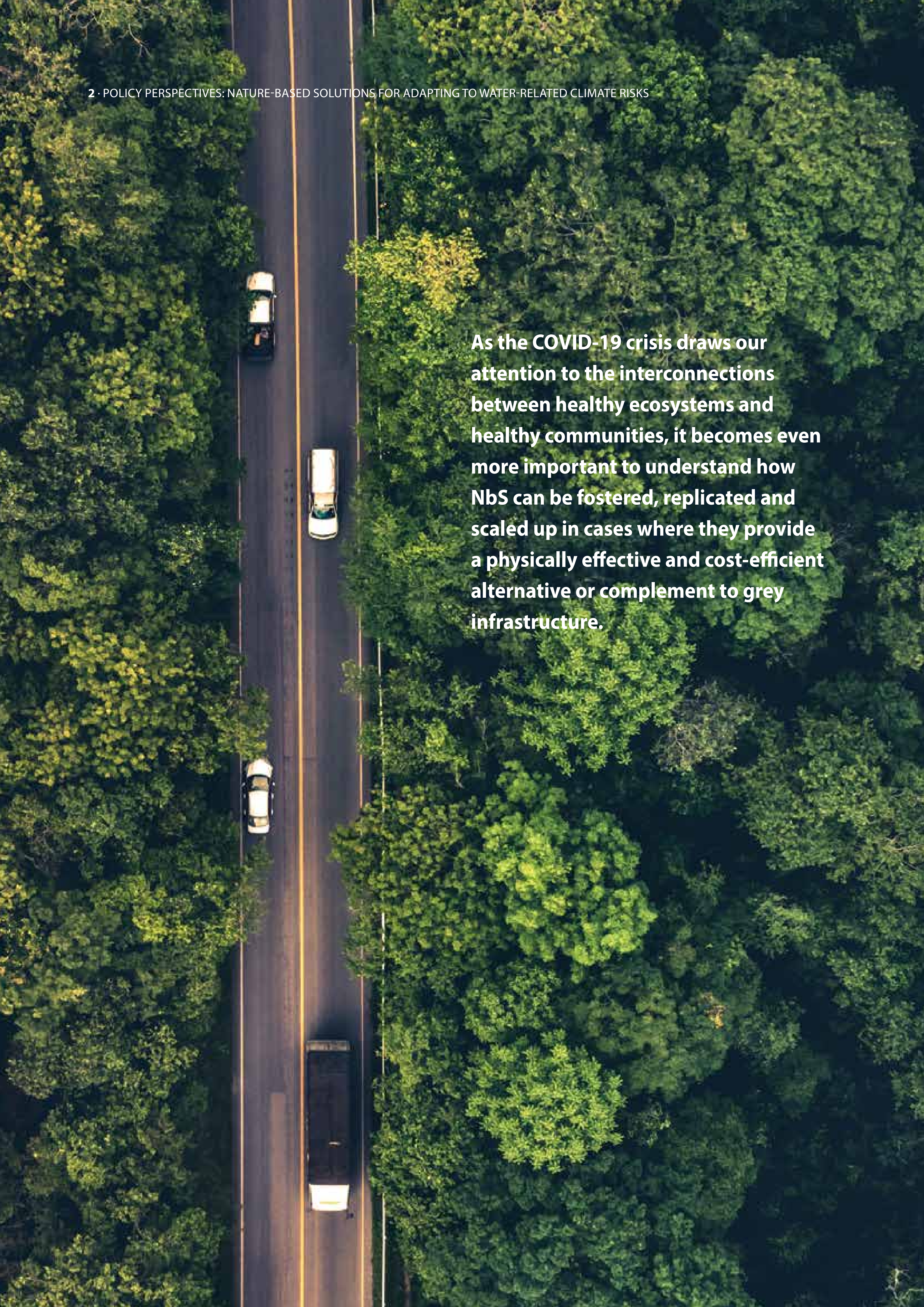


As the COVID-19 crisis draws our attention to the interconnections between healthy ecosystems and healthy communities, it becomes even more important to understand how NbS can be fostered, replicated and scaled up in cases where they provide a physically effective and cost-efficient alternative or complement to grey infrastructure.

1 Introduction

Countries are facing a pressing, complex and interlinked set of environmental crises. While significant government resources and capacities need to focus on managing the social and economic consequences brought on by efforts to manage the COVID-19 pandemic crisis, the global environmental challenges of climate change and biodiversity loss remain urgent. Recent major international reports (e.g. IPCC (2018, 2019), IPBES (2019)) have highlighted the extent and severity of the climate impacts the world faces even if stringent mitigation action is implemented, with the possibility of far worse outcomes under higher emissions trajectories. At the same time, global biodiversity is rapidly declining and ecosystem health deteriorating due to human activities. This policy paper focuses on the role of nature-based solutions (NbS) in limiting and managing the current and future impacts of climate change, focusing on water-related risks. It will highlight how NbS may also support a greening of the recovery from the COVID-19 crisis.

The international community is increasingly exploring the use of NbS to maximise the synergies between ecosystem health and human wellbeing, while also offering attractive economic benefits. Both research and cases of early adoption have presented evidence of the value and multiple benefits of NbS. Protecting coastal marshes can provide multiple ecosystem services including flood abatement, carbon and nutrient sequestration, water quality maintenance and habitat for fish, shellfish, wildlife and flora (Narayan et al., 2016[1]). Restoring forests in upper catchments can help to protect communities downstream from flooding, while simultaneously increasing carbon sequestration and protecting biodiversity (Filoso et al., 2017[2]). These multiple benefits can provide economic dividends. In Korea, for example, investing in afforestation in the 1970s both created immediate jobs and yielded an estimated net present value of over USD 50 billion in 2010, due to a significant reduction of disaster risk and increase in carbon sequestration (Lee et al., 2018[3]).

Despite growing international interest, recent investigations into the use of NbS have found that their uptake remains limited (Kapos et al., 2019[4]; Browder et al., 2019[5]). While many examples of individual NbS projects exist across countries, they are usually disconnected pilot projects and applied at a relatively small scale (Trémolet S. et al, 2019[6]). In contrast to grey infrastructure, the use of NbS has not been mainstreamed into the set of solutions and options that are currently considered by governments, local authorities or the private sector in different policy areas.

As the COVID-19 crisis draws our attention to the interconnections between healthy ecosystems and healthy communities, it becomes even more important to understand how NbS can be fostered, replicated and scaled up in cases where they provide a physically effective and cost-efficient alternative or complement to grey infrastructure. Recent studies have identified potential barriers in the enabling environment that can prevent NbS from being considered on equal footing with grey options. This paper and subsequent OECD work on the topic aims to explore these barriers to allow NbS to be more systematically considered in decisions taken by governments, local authorities or the private sector.

To refine the discussion, this OECD policy paper focuses on the use of NbS for addressing water-related climate risks, and specifically examines coastal flooding, riverine flooding, urban flooding and drought. Since the bottlenecks may be similar across other application areas, the policy framework that will be presented herein is meant to inform the broader set of issues for which NbS can be considered. The rest of the paper is organised as follows. Section two provides an introduction to the concept of NbS. Section three focuses on the role of NbS in reducing the water-related exposure to climate risks, and provides an overview of their uptake to date in OECD countries. Section four explores why prevailing decision making frameworks may fail to adequately consider NbS, and section five examines how NbS have been integrated in policy frameworks to date. This analysis then informs section six, which builds a policy evaluation framework intended to structure the cross-country comparative analysis of future case studies.

NbS are measures that protect, sustainably manage or restore nature, with the goal of maintaining or enhancing ecosystem services to address a variety of social, environmental and economic challenges.

2 Nature-based solutions: defining the concept

NbS seek to promote the maintenance, enhancement and restoration of ecosystems as a means to simultaneously address a variety of social, economic and environmental challenges. The International Union for Conservation of Nature (IUCN) first defined the term in the early 2000s as "*actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*" (Cohen-Shacham et al., 2016[7]). The European Commission (EC) provides a complementary definition and defines NbS as *"actions inspired by, supported by or copied from nature and which aim to help societies address a variety of environmental, social and economic challenges in sustainable ways"* (Bauduceau et al., 2015[8]). Whereas the IUCN definition emphasises the importance of nature conservation and restoration, the EC offers a broader perspective and focuses on sustainability in general[1]. We therefore would like to suggest a combination of the two definitions to frame our work going forward: NbS are measures that protect, sustainably manage or restore nature, with the goal of maintaining or enhancing ecosystem services to address a variety of social, environmental and economic challenges.

The concept of NbS is fundamentally based on the understanding that natural and managed ecosystems produce a diverse range of services on which human wellbeing depends. For example, floodplains and wetlands can protect communities from floods through increasing water retention (an ecosystem service), while simultaneously providing additional co-benefits, such as recreational value and an increase in biodiversity. Ecosystem services include supporting, provisioning, regulating, and cultural services that directly and indirectly affect people. These range from storing carbon, controlling floods and stabilising shorelines and slopes, to providing clean air and water, food, fuel, medicines and genetic resources (Millennium Ecosystem Assessment, 2005[9]).

Table 2.1 gives examples of different NbS, and the multiple services they can provide. A key element of NbS is that they are human interventions aimed at addressed societal challenges, such as minimizing disaster risk, or improving water quality. Therefore, an NbS will often entail a deliberate choice over the relative priority of different types of ecosystem services. The number of services and the strength of the interactions presented Table 2.1 depend on the selected NbS intervention, its location, and the scale of implementation.

TABLE 2.1. **NbS can have multiple benefits**

	ASSOCIATED ECOSYSTEM SERVICE							
EXAMPLES OF NbS	Coastal protection	Reduction in riverine flood impacts	Reduction in urban flood impacts	Filtering pollution	Carbon Sequestration	Habitat creation	Heat mitigation	Recreational opportunities
Protecting/ restoring coastal habitats (e.g. mangroves, salt marshes, coral and oyster reefs)	●			●	●	●		●
Protecting/ restoring upland forests		●	●	●	●	●	●	●
Creating parks and open green space			●	●		●	●	●

Note: List of NbS and services is not exhaustive

All NbS have an impact on biodiversity[2], and conversely, the functionality of an NbS itself can be impacted by biodiversity. While some NbS actively aim to enhance biodiversity so as to enhance the ecosystem service provided, such as the restoration of diverse oyster reefs for flood protection benefits, others may prioritise a different ecosystem function over biodiversity, such as the planting of non-native monocultures that enhance carbon sequestration, but that have a negative impact on local biodiversity (Seddon et al., 2018[10]). However, NbS that do not support biodiversity may be more susceptible to environmental change in the long term, and therefore less resilient. Ensuring an NbS supports biodiversity, such as functional diversity, can serve to bolster ecosystem functioning, and therefore provide stability against disturbances (Isbell et al., 2017[11]).

NbS can be considered as an 'umbrella concept' for other approaches such as ecosystem-based adaptation (EbA), eco-disaster risk reduction (eco-DRR), green infrastructure (GI) and natural climate solutions (NCS). While each approach differs slightly, (see Table 2.2), a commonality across these concepts is that they are often defined in *contrast* to grey infrastructure[3]. In the context of flooding, for example, grey infrastructure refers to built structures such as dams, dikes, channels and storm surge defences. Different terms tend to be used by different users, and there is no one set definition used by countries. The Government of Canada, for example, tends to include clean energy in their definition of green infrastructure, and often uses the term living green infrastructure to cover concepts similar to NbS (Canada, 2016[12]). The European Union uses a variety of terms in their policy documents, and the Flood Directive refers to "Natural Flood Retention Measures" (NFRM), whereas The EU Strategy on Adaptation to Climate Change (2013) calls on Member States to make Europe more climate resilient by deploying ecosystem-based approaches to adaptation.

NbS encompass a wide range of actions, such as the protection and management of the natural environment, the incorporation of green infrastructure in urban areas and the application of ecosystem-based principles to agricultural systems (Eggermont et al., 2015[17]). Interventions range from minimal or no interventions, including protection and conservation, and monitoring strategies; to management approaches to develop ecosystems and optimise the generation of chosen ecosystem services, such as planning agricultural landscapes to minimise drought; and finally highly intensive management approaches, including those aimed at the creation of entirely new ecosystems, such as greening buildings or creating new green spaces (Eggermont et al., 2015[17]).

TABLE 2.2. **Comparing similar concepts to NbS**

Concept	Definition*	Link to the concept of NbS
Green infrastructure (GI)	"A strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation" (EC, 2019[13]).	GI is a type of NbS. Although GI can be used in a rural context, it is most frequently associated with urban areas.
Ecosystem-based adaptation (EbA) and disaster risk reduction (Eco-DRR)	"Physical measures or management actions that utilise natural or ecosystem-like processes to adapt to a variety of climate hazards" (EC, 2017[14]).	EbA/Eco-DRR are NbS that primarily focus on reducing vulnerability and build resilience to the impacts of climate change.
Natural climate solutions	"Conservation, restoration, and improved land management actions that increase carbon storage and/or avoid greenhouse gas emissions across global forests, wetlands, grasslands, and agricultural lands" (Griscom et al., 2017[15])	Natural climate solutions are NbS that focus on nature conservation and management actions that reduce greenhouse gas emissions from ecosystems and harness their potential to store carbon
Natural Capital and natural assets	"The world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible" (Natural Capital Coalition, n.d.[16]),	Natural capital can be considered the "asset base" on which NbS are built.

Note: *None of the concepts listed has a single uncontested definition, therefore definitions that are frequently cited or used in policy documents were selected as a proxy.

NbS are often referred to as an innovative way to address societal problems, however, they do not include exclusively "new" solutions. While NbS can offer new opportunities to incorporate ecosystem considerations into a range of policy challenges, they also encompass existing ideas and knowledge. For example, Indigenous communities in Australia have been looking after and conserving the country's lands for tens of thousands of years, with wetlands playing a particularly significant role (Australian Government, 2016[18]). Indigenous People's knowledge systems are rooted in nature and the respect of all life forms, and frequently incorporate techniques and approaches that have recently become labelled as NbS.

This is the first OECD contribution that examines the use of NbS explicitly. Previous OECD work on climate has touched on the role, benefits and limitations of NbS from various angles: On climate change adaptation, work has emphasised that NbS are increasingly being considered and used to meet the need for flexible and cost-effective climate-resilient infrastructure (OECD, 2018[19]). Work on coastal adaptation included NbS as a key tool available to countries to manage the impacts of sea level rise. The OECD Council Recommendation on Water highlights the use of ecosystem-based approaches as a cost-effective way of improving water quality and managing flood and scarcity risks. Ecosystem-based approaches are encouraged across the Recommendation, in particular through improved policy coherence across water management and land use, including ecosystem and biodiversity protection (OECD, 2016[20]). OECD work on climate change mitigation has highlighted NbS as a tool to foster a systems approach that can be applied across economic sectors, such as health, recreation or housing (OECD, 2019[21]).

This paper builds on existing OECD work by clearly framing the policy challenges of NbS deployment. While NbS can be used to address a range of challenges, such as illustrated above, the application area this paper focuses on is water-related risks, which for the purpose of this paper are defined as coastal flooding and erosion, river (fluvial) flooding, urban flooding, and drought.

BOX 2.1. **International efforts to promote the use of NbS**

Recent international agreements on climate and disaster risk have highlighted the interconnections between ecosystems and societal vulnerability, as well as the role nature can play in managing increasing environmental risks. These include, for example:

- The Paris Agreement on climate change calls on all parties to acknowledge "the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity, recognised by some cultures as Mother Earth".
- The United Nations Convention for Biological Diversity at its 14th Conference of the Parties formally decided to integrate climate change issues into national biodiversity strategies and vice versa, bringing important interdependencies to light.
- The Sendai Framework for Disaster Risk Reduction (2015-2030) recognises the need to shift from primarily post-disaster planning and recovery to the proactive reduction of risks, and specifies that strategies should consider a range of ecosystem-based solutions.

On the basis of these agreements, high-level efforts have advocated for the use of NbS. The 2018 United Nations World Water Development Report focused on NbS, calling on countries to scale up implementation. The 2019 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Report and the Climate Change and Land Report of the Intergovernmental Panel on Climate Change endorsed the use of NbS to address climate related issues. Furthermore, the Global Commission on Adaptation highlighted the critical interdependence between healthy ecosystems and societal resilience, and NbS are one of their areas of focus for the 2020 year of action on adaptation. NbS were one of the nine key action areas for the United Nations Climate Action Summit that took place in September 2019 . Finally, the IUCN is developing a global standard for NbS, to be released at the World Conservation Congress.

Sources: Paris Agreement to the United Nations Framework Convention on Climate Change, Dec. 12, 2015, T.I.A.S. No. 16-1104; IPBES (2019), "Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services."; WWAP (2018), *The United Nations world water development report 2018:* nature-based solutions for water - UNESCO Digital Library, https://unesdoc.unesco.org/ark:/48223/pf00002961424.

3 The use of NbS to manage water-related risks

The economic and social costs of risks related to flooding and drought are high and increasing. For the past 10 years, water hazards related to extreme weather have routinely been in the top five risks in terms of likelihood and severity of impact in the World Economic Forum's global risk assessment (World Economic Forum, 2019[22]). In 2018, flooding was responsible for global economic losses of over USD 37 billion, while drought was responsible for approximately USD 28 billion (Aon, 2018[23]).

There is a significant and growing body of scientific evidence documenting that climate change will intensify the risks of water-related hazards. By creating a warmer lower atmosphere, climate change is altering the water cycle through an increase in evaporation, evapotranspiration and precipitation and changes to atmospheric circulation, which can lead to wet regions becoming wetter while dry regions become drier (European Environmental Agency, 2018[24]).

Compounding these risks, a deteriorating natural environment worldwide is increasing vulnerability to water-related hazards. A range of interlinked pressures, such as the loss and degradation of natural areas like wetlands, soil sealing and the densification of built-up areas are undermining ecosystem functionality (Kabisch et al., 2016[25]). This challenges the provisioning of ecosystem services, resulting in negative impacts on human well-being.

To reduce the exposure to water-related risks, countries have made significant investments in grey infrastructure, such as dikes or dams. While they have provided

FIGURE 3.1. **Climate change and ecosystem degradation are compounding water-related risks**

Ecosystem degradation, through the over exploitation of natural resources and destruction of coastal habitats is increasing vulnerability to damage from coastal storms and slow-onset events (OECD, 2019[26]).,For example, the loss of mangroves on a global scale by 1 to 2 percent each year is significantly increasing the vulnerability of coastal communities to coastal storms (Carugati et al., 2018[27]). Climate change is also driving of future coastal hazards. Global modelling finds that without any kind of adaptation, coastal flood damage under higher-end sea-level rise (1.3 metres) could be equivalent to 4 per cent of world GDP by 2100 (OECD, 2019[26]).

Climate change is expected to increase river flood risks. In Europe, for example, climate models consistently show a substantial increase in flood risk across most Western and Central countries, which could increase the annual directly affected population from 200 000 to 360 000 people (Rojas, Feyen and Watkiss, 2013[28]). Ecosystem degradation is additionally compounding vulnerability to river floods. In most large rivers in the world, natural floodplains have been disconnected from rivers, through upstream dams for example, leaving only 37 per cent of rivers longer than 1,000 kilometres to flow freely over their entire length (Grill et al., 2019[29]).

As urban populations grow and climate change shifts rainfall patterns, communities are increasingly at risk of urban flooding. Global urban property damage from flooding alone costs around USD 120 billion per year (Browder et al., 2019[5]). The occurrence of heavy rain is projected to occur almost twice as often with each further degree of warming, and the total amount of precipitation from these events is also likely to roughly double per degree At the same time, built-up areas have increased by 15 per cent in OECD countries since 2000 (OECD, 2019[30]).

The frequency, intensity and duration of droughts have been steadily increasing in recent years. In 2015–16, the El Niño weather phenomenon caused the worst and most damaging droughts around the world (WWAP, 2018[31]). In Europe alone, areas and people affected by droughts increased by 20 per cent between 1976 and 2006 at a cost of EUR 100 billion (OECD, 2015[32]). In the United States, half of the 50 fastest –growing cities are located in the drought-prone South (OECD, 2015[32]). Environmental degradation and human practices contribute to increased exposure and vulnerability to drought and water scarcity. For example, deforestation in the Amazon could develop a weather cycle consisting of abnormally dry air creating drought conditions in western North America (Medvigy et al., 2013[33]).

protection and other vital services on which human lives depend, such as regulating water supply and generating hydropower in the case of dams, they equally have limitations. First, grey infrastructure can be costly to build and to maintain (Wingfield et al., 2019[40]), and when it fails, it has shown to cause signficant ripple effects. Second, grey infrastructure is long lasting and inflexible, and in the past has been designed assuming static hydro-climatic conditions. For example, coastal defences have become increasingly expensive to adapt to rising sea levels (e.g. by widening or raising) and to maintain over time (Driessen et al., 2016[34]; Keeler, McNamara and Irish, 2018[35]). The high costs of adapting inflexible grey investments can lead to vulnerability to failure under changing climatic conditions. This puts large, costly infrastructure projects at risk of becoming 'stranded assets', failing to deliver their designed services when conditions change, with potential catastrophic consequences (such as a dam breach) (OECD, 2013[36]). Finally, grey infrastructure can undermine the ability of natural systems to regenerate – for example, coastal dikes can intensify land subsidence and prevent the natural accumulation of sediments by tides, waves and wind (Temmerman et al., 2013[37]).

There is increasing evidence on the performance of NbS to reduce water-related risks, highlighting features which make NbS particularly well suited for adapting to changing climatic conditions (Kabisch et al., 2016[25]; Nesshöver et al., 2017[38]; Kapos et al., 2019[4]).

These include:

- NbS may be a "no-regrets" adaptation measure, as they can yield benefits even in the absence of climate change (Hallegatte, 2009[39]), making them an effective way to cope with climate variability and change. For example, urban parks can reduce the urban heat island effect and absorb floodwater, while providing recreational value, improving air quality, and making a space more economically attractive (Brown and Mijic, 2019[40]).
- NbS can assist in managing uncertainty related to climate change by avoiding or delaying lock-in to capital-intensive grey infrastructure, allowing for flexibility to adapt to changing circumstances (OECD, 2013[36]). For example, a floodplain may attenuate larger flood volumes than can be held within a levee lined river channel, with co-benefits of sustaining bird and fish species and providing recreational benefits to people (World Bank, 2017[41]). Another example is emerging evidence that mangroves can keep pace with moderately high rates of sea-level rise (Woodroffe et al., 2016[42]).

BOX 3.1. **The economic argument for NbS**

There is growing evidence of the economic benefits of maintaining natural habitats through avoided losses to water related disasters. For example, in the Northeast of the United States, protected coastal wetlands are estimated to have helped prevent over USD 600 million of direct property damages during Hurricane Sandy (The Nature Conservancy Business Council, 2019[43]). Globally, it is estimated that without mangroves, 15 million more people would suffer from flooding annually (Menéndez et al., 2020[44]).

Research has shown that in some cases, NbS can be more cost-effective than grey alternatives, and in particular for less extreme hazards. For example, across 52 coastal defence projects in the United States, NbS were estimated to be 2-5 times more cost-effective than grey infrastructure, and most effective to defend against waves up to half a metre high and at increased water depths (Narayan et al., 2016[1]). However, studies which compare the value of NbS to alternative approaches are rare, and economic appraisals often do not properly capture or value the full suite of co-benefits of an NbS.

In addition to reducing losses and damages, the multiple co-benefits of NbS can have significant economic value. For example, in Europe, it was found that restored rivers, in addition to increasing flood protection, enhanced agricultural production, carbon sequestration and recreation, yielding an estimated net societal economic benefit over unrestored rivers of an estimated EUR 1400 per hectare per year (Vermaat et al., 2015[45]).

Finally, investments in NbS can stimulate the economy by creating jobs, much the same way as investments in grey infrastructure. For example, the American Recovery and Reinvestment Act of 2009 financed coastal habitat restoration projects that yielded 17 jobs per million dollars invested (Edwards, Sutton-Grier and Coyle, 2013[46]). In the European Union, it is estimated that restoring 15% of degraded ecosystems, consistent with Target 2 of the EU 2020 Biodiversity Strategy, would result in between 20 000 and 70 000 full-time jobs (OECD, 2019[47]).

- The benefits of NbS have been found to outweigh the costs of implementation and maintenance in a range of contexts (see Box 3.1 for more detail).

- NbS can increase the effectiveness and operable life of grey infrastructure. For example, integrating NbS into grey flood control measures can increase water absorption capacity, reduce velocity, and regulate peak flows (Browder et al., 2019[5]). In the Odra basin in Poland, natural flood retention areas (dry polders) were combined with traditional flood embankments to protect against the recurrence of a very severe (1,000-year) flood (Browder et al., 2019[5]).

NbS IN PRACTICE

The following section provides an overview of types of NbS by OECD countries to manage water-related risks across the areas of coastal, river, urban flooding, and drought. The objective is to demonstrate the range and scale of existing NbS, without being comprehensive (Box 3.2).

NbS to manage coastal flood and erosion control

The United States has been a pioneer in the use of coastal wetlands to regulate water flows and prevent coastal flooding, as well as reduce damage from storm surges and erosion. For example, San Francisco is restoring over 8,000 hectares of marshes to protect its coastline and prevent erosion (Lubell, 2017[48]). As of 2019, 40 per cent of the land had already been restored, and the project had managed to maintain its current flood protection levels (South Bay Salt Pond Restoration Project, 2019[49]).

Many countries have adopted NbS as a strategy for adapting to coastal hazards, including Mexico, the United Kingdom and New Zealand. In Quintana Roo, Mexico, a group of public and private stakeholders worked to implement artificial reefs and sand-dune restoration to prevent coastal erosion, bringing economic benefits to nearby tourism operators, as well as and restore previously damaged fish habitat (Silva et al., 2017[50]). The United Kingdom has implemented many natural coastal flood management measures, such as in Medmerry,

BOX 3.2. The challenges for making a comprehensive assessment of the use of NbS and existing case-study databases

Acquiring a comprehensive picture of the use of NbS to date is difficult. First, there is no one metric to there is not yet a common understanding of what NbS is. Second, most NbS initiatives are implemented at the local level by different stakeholders, which makes them difficult to track.

Despite these limitations, over recent years, multiple initiatives have attempted to map out NbS pilots to provide practitioners with evidence on how, and what scale, NbS can effectively address different societal challenges (e.g. water-related risks, climate change). These initiatives include:

- Under the EU Framework Programme for Research and Innovation, the ThinkNature Platform is a multi-stakeholder communication platform supporting the understanding and promotion of NbS. This platform focuses on sharing lessons learned from small-scale projects and giving insight into implementation.

- The European Union Natural Water Retention Measures (NWRM) platform provides a comprehensive database of NbS to address flood risk, with technical specifications and over 100 case studies applications throughout the EU.

- The Nature-Based Solutions Evidence Tool, developed by the University of Oxford, is a database of systematically peer reviewed literature on NbS projects. Based on this tool, the top 10 countries with the highest amount of peer reviewed case studies are China, The United States of America, Kenya, Spain, The United Kingdom, Australia, Canada, Germany, Portugal and Austria.

- Created by the U.S. Army Corps of Engineers, Engineering with Nature: An Atlas is a compilation of 56 projects in the United States that show the benefits and diversity of NbS, as well as how they can be implemented.

- The Natural Capital Project out of Stanford University develop science tailored to fill technical gaps around NbS deployment

While the case study databases highlighted can provide an indication of the types of steps being taken by countries, they do not provide a conclusive picture of uptake or performance to date.

Sources: ThinkNature (n.d), ThinkNature Platform, https://platform.think-nature.eu/ (accessed 26 June 2020) ; Natural Water Retention Measures (NWRM) Platform (n.d), European NWRM Platform, http://nwrm.eu/ (accessed 26 June 2020); Nature-based Solutions Evidence Tool (n.d), Nature-based Solutions Evidence Platform, https://www.naturebasedsolutionsevidence.info/ (accessed on 26 June 2020) ; Engineering with Nature: An Atlas (n.d), EWN | An Atlas, https://ewn.el.erdc.dren.mil/atlas.html (accessed on 26 June 2020) ; Natural Capital Coalition (n.d.), Natural Capital Coalition | Natural Capital, https://naturalcapitalcoalition.org/natural-capital-2/ (accessed on 28 October 2019).

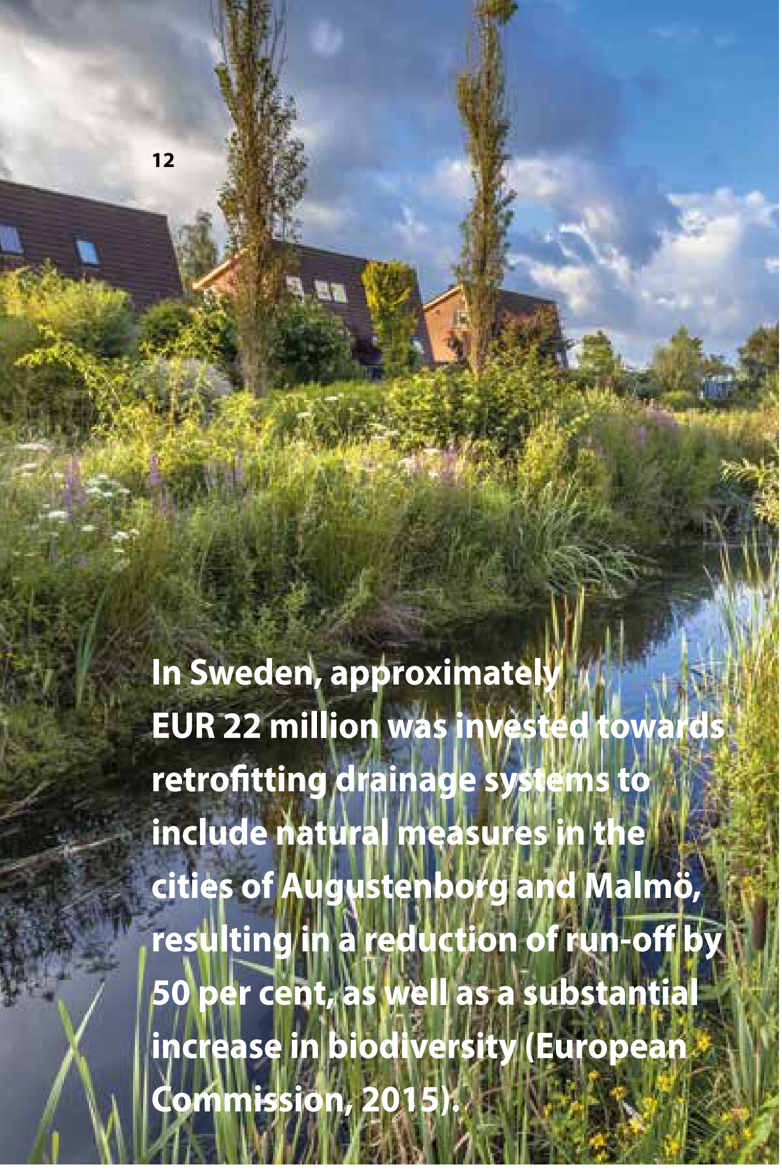
where a GBP 28 million programme created a nature reserve to protect nearby communities from the effects of coastal storms (UK Environment Agency, 2017[51]). In New Zealand, communities have restored coastal dunes in the Bay of Plenty by planting native sand-binding vegetation (MoE, 2008[52]).

NbS to address river flooding

The Netherlands Room for the River programme is an example of large-scale planning that incorporates NbS. Recognising that extremely high river discharges for the Rhine tributaries will occur more frequently in the future with climate change, the programme ran from 2007 to 2018 with a budget of EUR 2.3 billion (IHE Delft Institute for Water Education, 2013[53]). The programme was designed to restore the natural floodplains of rivers along certain non-vulnerable stretches, diverting rivers and creating water storage areas, in order to protect the most developed riparian areas. The restored wetlands both provided additional storage and safeguarded biodiversity, while enhancing aesthetic and recreational opportunities. (Trémolet S. et al, 2019[6]).

Other examples of river restoration include the Sigma Plan, launched in 1976 in Belgium, which aims at protecting communities that live near the Scheldt River. As of 2015, the Sigma Plan consisted of 1200 hectares of designated natural flood zones (Climate ADAPT, 2016[54]). In France, starting in 2010, both the Viredonne and Dardaillon rivers underwent restoration to help regulate riverine flooding during extreme rain events. Over 10 kilometres of riverbanks and 10 hectares of wetlands were restored in total (Onerc, 2019[55]). By replanting vegetation and moving riverbeds, the goal was to limit heavy flooding and benefit biodiversity.

Countries have been investing in the restoration and conservation of inland wetlands as a river flood management technique. For example, Canada has a dedicated fund for conserving its wetlands in the province of Saskatchewan, with the explicit purpose of flood control. (OECD, 2019[56]). Similarly, after seeing a 92 per cent drop in its wetlands due to rice paddies and other forms of agriculture, Japan has focused on conserving the Kabukuri-numa wetlands in the northern part of the country in order to use them as a flood-control basin, increasing their size from 100 hectares to 150 hectares (IUCN, 2019[57]). Dry ponds, the planting of trees, gullies and earth bunds are other measures frequently used by countries, and the United Kingdom provides a good example. By implementing these techniques, the Cotswolds region reduced peak water level by 1.4 meters when comparing a storm in 2016 to one in 2014 (Short et al., 2019[58]).



In Sweden, approximately EUR 22 million was invested towards retrofitting drainage systems to include natural measures in the cities of Augustenborg and Malmö, resulting in a reduction of run-off by 50 per cent, as well as a substantial increase in biodiversity (European Commission, 2015).

NbS to manage urban flooding

A common way of managing urban flooding is by implementing green drainage systems, often referred to as SuDs (sustainable urban drainage systems). Scotland and Wales have legislation making it obligatory for developers to incorporate such systems into their projects, and England and Ireland have been successful in encouraging their uptake despite not having policies enforcing their use (Susdrain, n.d.[59]). One particular example is the city of London, where several types of green drainage systems have been implemented, including rain gardens, permeable paving, and infiltration trenches (Susdrain, n.d.[60]). The Netherlands has promoted green drainage systems in their Water Act that provides recommendations on how to effectively manage stormwater through SuDs (Beenen AS and Boogaard FC, 2007[61]). In Sweden, approximately EUR 22 million was invested towards retrofitting drainage systems to include natural measures in the cities of Augustenborg and Malmö, resulting in a reduction of run-off by 50 per cent, as well as a substantial increase in biodiversity (European Commission, 2015[62]). In the city of Portland, Oregon, a USD 8 million investment in green alleys and tree planting was estimated to have saved USD 250 million in stormwater infrastructure costs (Foster, Lowe and Winkelman, 2011[63]).

When adapting to urban flooding, another technique is the installation of green roofs, which has been encouraged through legislation at the local level. In Toronto, Canada, the local government encouraged the use of this approach, and passed a bylaw in 2009 requiring that new developments larger than 2,000 m^2 in gross floor area have green roofs installed (City of Toronto, 2009[64]). Denmark provides a similar case, as according to Copenhagen's 2011 Climate Adaptation Plan, green roofs are mandatory for all structures with flat roofs built after the year 2010 (City of Copenhagen, 2011[65]). The uptake of green roofs has also increased in cities in the United States, with New York and San Francisco passing legislation requiring green roofs for certain developments, and Washington, D.C encouraging the use of green roofs through its stormwater management regulations (New York City, n.d.[66]) (San Francisco, 2017[67]) (DC.Gov, 2019[68]).

NbS to manage water scarcity and droughts

One way in which NbS can be used to protect regions from risks posed by drought is through increasing and maximising water storage capacities, and thus slowing the release of water (WWAP, 2018[31]). This is seen in the western United States, where beaver restoration projects have been pursued in order to take advantage of certain benefits provided by their dams. For example, beaver habitats have the ability to lengthen the residence time of water, which can increase groundwater recharge and aid in the creation of wetlands. In the Kumamoto region of Japan, abandoned rice fields have been used to recharge local groundwater supplies, eventually leading to the creation of a payment for ecosystem services scheme (PES) that consists of major groundwater users paying farmers on a monthly basis for their resources. Largely considered to be a success, this project has more than doubled in size in 14 years, from just under 300 hectares of land being used per month in 2014, to over 600 hectares per month being used in 2018 (GRIPP, 2018[69]) (UNDESA, 2013[70]).

Turkey has used forest conservation and management in the Konya region and the Seyhan Basin to help the areas adapt to the effects of climate change, including resilience to drought and the reduction of water stress (IUCN, 2019[71]). In Greece, local municipalities and the EU collaborated under the LIFE Project, an endeavour that aimed to protect watersheds and banks along the Eurotas River while simultaneously restoring riparian forest. The primary goals were to increase filtration and reduce the risk of drought, with the restoration of every 100 meters costing approximately EUR 10,000 (Oppla, n.d.[72]).

4 The need to adjust traditional enabling environments to foster the use of NbS

The discussion of application areas of NbS to reduce water-related risks shows a rich set of options available to use and enhance nature as an effective resilience building measure, both alongside grey infrastructure or as self-standing solutions. It additionally highlights that NbS can be physically effective, cost-efficient and multifunctional.

While the review of applications is not a comprehensive assessment of the extent to which OECD countries have implemented NbS to manage water-related disasters, is does give an indication that the majority of NbS implemented on the ground have been launched as one-off projects. This is reinforced by recent studies which have found that NbS are usually implemented on a pilot basis and in an ad hoc way (Kapos et al., 2019[4]; Browder et al., 2019[5]; Trémolet S. et al, 2019[6]; Wingfield et al., 2019[73]). These projects tend to benefits from vested supporters, but often lack the policy and financial framework to apply them more systematically, more frequently, and at larger scale. The following section discusses the characteristic of NbS which makes them unique from grey infrastructure, followed by how current policy environments consider NbS.

ADJUSTING POLICIES TO THE UNIQUE CHARACTERISTICS OF NbS

NbS have fundamental characteristics and requirements which differentiate them from grey infrastructure (see Table 4.1), such as long time scales until intended benefits develop, large spatial scales, dynamic uncertainty, and diffused benefits. These characteristics, can lead to NbS being a "bad fit" for decision making within institutional, regulatory and financial processes that have all been developed with grey infrastructure in mind. Traditional enabling environments (institutional, regulatory and financial) can therefore inadvertently discourage the use of NbS.

While NbS do not always emerge through traditional enabling environments for reasons discussed below, some of the unique characteristics of NbS are well suited to recovery measures. For example, while it can take longer for the full intended benefits of an NbS to materialize (such as decreased erosion and improved water quality), their initial steps, such as restoration, can be quick to implement requirements (Hepburn et al., 2020[36]). In addition, while it can be difficult to measure (and capture) co-benefits, the ability of NbS to achieve multiple policy goals with one intervention can make them particularly appealing public investments.

Time scales

Some NbS, especially those involving the restoration of badly degraded ecosystems, can be slow to develop their adaptation benefits or deliver potential co-benefits in full. While grey infrastructure reach their desired protective benefit immediately upon finalisation of

TABLE 4.1. **Unique characteristics of NbS compared to grey infrastructure**

Characteristics	NbS	Grey Infrastructure
Time scales	Long time horizons for benefits to materialise	Benefits are realised straight after construction
Spatial scales	Often implemented at landscape scale to be effective, crossing jurisdictional boundaries	Implemented "within the fence line" of jurisdictions
Performance reliability	Performance uncertainties are can be unknown due to complex natural systems	Performance uncertainties are "known"
Quantification of benefits	Many co-benefits difficult to quantify (e.g. human health and livelihoods, food and energy security biodiversity)	Benefits easy to quantify (e.g. avoided damage to assets)

construction, the growth rate of the living components, such as forests, takes much longer to fully reap their full protective benefit. (Kabisch et al., 2016[25]). At the same time, the adaptability of NbS over time make them appreciate in value as opposed to the high depreciation costs associated with grey infrastructure. The challenge though is that NbS may not yield the risk reduction effects in the time frame policy makers would hope for (World Bank, 2017[74]).

Spatial scales

The spatial scale considered for planning NbS substantially affects their ability to deliver expected outcomes. The integrity and health of ecosystems at landscape scales determine the potential of NbS to be effective, as ecosystems are highly dependent on the larger enabling environmental processes (Calliari, Staccione and Mysiak, 2019[75]). For example, the alteration of upstream sediment loads may influence downstream coastline stability, which in turn determines the success and feasibility of downstream or coastal interventions. Often, NbS cannot be sustained by managing individual sites in isolation, as the delivery of associated ecosystem services might depend on processes taking place on a larger scale (World Bank, 2017[74]). In some cases, a certain size of ecosystem may be needed for it to be resilient to various pressures and therefore continue to provide services in future. However, the appropriate scale is unique to each NbS. For example, empirical evidence suggests that natural water retention measures can be effective in small catchments, but may not have the same effectiveness when up-scaled to larger areas (Collentine and Futter, 2018[76]). Finally, there are inherent tradeoffs in the use of NbS as the space dedicated to NbS often implies the land cannot be used for another productive use.

Performance reliability

Ecosystems are not static, as they are made of living components that change over time. This can be a benefit, as it means NbS can adapt to changing environmental and risk conditions, thereby potentially exceeding the design lifetime of grey infrastructure (World Bank, 2017[74]). However, the dynamism of NbS also introduces new sources of uncertainty, which can increase the difficulty in developing solid predictions about the level of service provided.

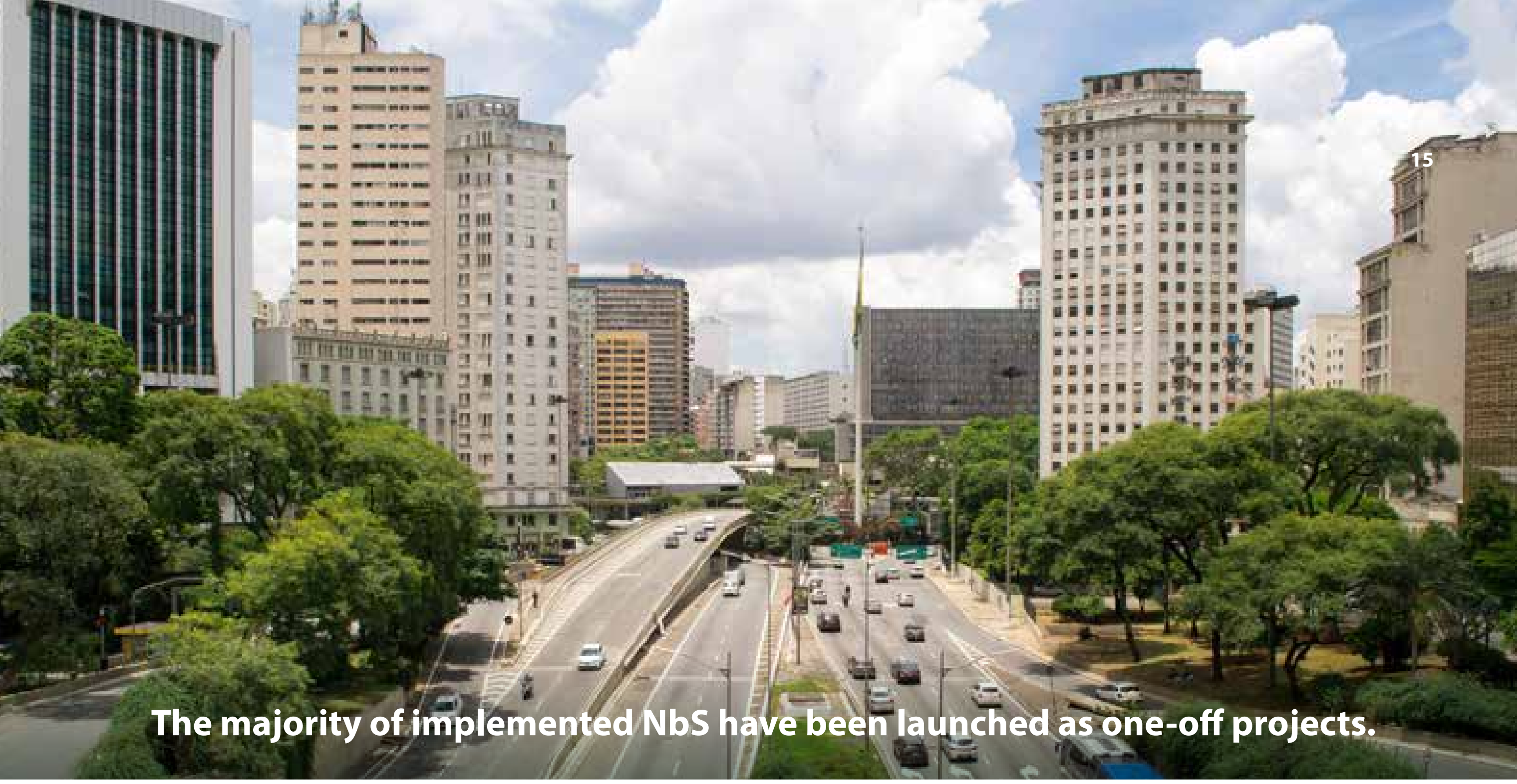
NbS implemented for climate adaptation purposes may themselves be climate-sensitive. For example, coral reefs However, the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5C found that between 70 and 90 per cent of coral reefs would be lost if the temperature increased to 1.5C, and more than 99 per cent if temperature increased by 2C (2018[77]). Peatlands, as another example, provide valuable ecosystem services through flood management and carbon sequestration (Shuttleworth et al., 2019[78]), but are highly sensitive to climatic change (Bonn et al., 2016[79]). Therefore the success of NbS can only be achieved by ensuring management and restoration approaches take into account anticipated climate impacts as well as the tolerance of ecosystems to these impacts (Kapos et al., 2019[4]).

Quantification of benefits

In addition to their primary purpose, NbS generate ancillary social, economic and environmental co-benefits related to human health and livelihoods, food and energy security, ecosystem rehabilitation and maintenance, climate adaptation and resilience, and biodiversity (Browder et al., 2019[5]). While these co-benefits can be of great interest to the general public, the government and affected communities, they are often not reflected in the benefits assessment of traditional infrastructure investments. The existing methods for assessing, valuing and monitoring these co-benefits are often underdeveloped or challenging to apply (Trémolet S. et al, 2019[6]). There is additionally a wide variation in the hydrological and other services delivered by different ecosystem types (WWAP, 2018[31]), and specific costs and benefits of different solutions are dependent on local circumstances (Brown and Mijic, 2019[40]). Finally, there can be trade-offs between different ecosystem services. For example, enhancing the recreational capacity of a park may lead to pressures on its biodiversity through more intense use and associated disturbances.

POTENTIAL BLOCKS IN EXISTING INFRASTRUCTURE PLANNING AND INVESTMENT DECISIONS

Decisions around planning, implementing, operating, financing, and engagement for risk reduction infrastructure may need to be adapted if NbS are to be applied consistently and considered on an equal footing as grey measures. Box 4.1 highlights how prevailing decision-making frameworks could potentially prevent NbS from being considered and selected as a viable option to manage water related risks. As NbS are not systematically considered, this then leads to ad hoc projects, which in turn contributes to a low track record



for NbS, with sparse and case-specific performance data. A critical challenge persists for NbS in the availability and accessibility of the necessary performance data, which may not be collected at all, may be collected inconsistently or incompletely at different times, or across different spatial scales (Bush and Doyon, 2019[80]). Authorities charged with managing risks to communities will likely default to better known and tested solutions, in the absence of robust performance data for NbS (Dadson et al., 2017[81]).

BOX 4.1. **The characteristics of NbS can limit their consideration by governments, local authorities or the private sector when addressing water-related risks**

Stage of infrastructure development	Example of how the unique characteristics of NbS can limit their consideration
Planning and prioritisation of intervention	Delays to the accrual of benefits due to **time scales** mean that benefit-cost ratios are variable over time, oftentimes resulting in traditional cost-benefit assessments leading to skewed results for NbS. Assessing technical performance of an NbS, as well as its interaction with grey infrastructure, can be imprecise due to the inherent **dynamism** and complexity of natural systems.
Implementation of intervention	The **dynamism** of NbS can lead to policy makers, regulators and/or permitting agencies prioritising grey infrastructure over NbS because it is familiar and easily understood with respect to compliance and permitting.
Operation and maintenance of intervention	**Large spatial scale**s often mean NbS cross jurisdictions as well as sectoral responsabilities, causing confusion over responsibility. NbS often require the active support of local citizens and landowners, for example through tasks such as replanting trees or maintaining water retention structures. This is in contrast to the long-term operations and maintenance of grey infrastructure is typically the direct responsibility of the service provider. A reliance on a multitude of stakeholders can create additionally uncertainties about performance over time.
Securing financing	**Diffuse benefits** can render it challenging for private investment to create suitable revenue streams when many of the potential co-benefits are not traded in the market. In addition, the combination of inherent ecological dynamism and long timescales can create challenges with setting a payment schedule among beneficiaries, which can pose challenges to investors seeking short- or medium-term returns. Finally, most existing funding models do not match well to the need for continuous low-level investment over long time frames that characterise NbS.
Stakeholder engagement	**Large spatial scales** often require interventions that involve multiple stakeholders. The cost of engaging and negotiating with multiple stakeholders, working across regulatory jurisdictions and collaborating with dispersed landowners can be time consuming and costly. In addition, those responsible for providing the adaptation service (such as a flood management authority) may not have the capacity or legal legitimacy to engage with landowners.
Monitoring and evaluation	Monitoring green infrastructure that covers **large spatial areas** may require data collection and analysis across sectors as well as coordinated processing communication among agencies at different governance levels. Monitoring ecological trends may require a different set of expertise and metrics than would be used for conventional infrastructure.

Sources: Browder, G. et al. (2019), *Integrating Green and Gray*, https://openknowledge.worldbank.org/handle/10986/31430; WBCSD (2017), *Incentives for Natural Infrastructure*, World Business Council for Sustainable Development; Lukasiewicz, A., J. Pittock and M. Finlayson (2015), *Institutional challenges of adopting ecosystem-based adaptation to climate change*, Regional Environmental Change, http://dx.doi.org/10.1007/s10113-015-0765-6.; Kapos, V. et al. (2019), *The Role of the Natural Environment in Adaptation, Background Paper for the Global Commission on Adaptation*, Global Commission on Adaptation, Rotterdam and Washington, D.C

5 The integration of NbS in national policy frameworks to date

National governments play a key role in fostering the use of NbS. Governments need to design an institutional, policy, regulatory and financial enabling environment that facilitates the take up of NbS by both public agencies across levels of government as well as private actors. It is important for national governments to ensure that governance arrangements, regulations and technical capacity do not inadvertently discourage their use. In the following section, a scan of current policy provisions for NbS across OECD countries is provided. The scan focuses on national adaptation plans and strategies as well as a complementary OECD survey. To get a more complete picture of the integration of NbS in national policy frameworks, and their implementation progress in water-related risk management, other policy documents, regulations and financing mechanisms need to be additionally examined. In-depth country case studies will be carried as part of the OECD work on NbS to provide a more comprehensive assessment for a selected set of countries.

National adaptation plans provide a good entry point to understanding the policy priority given to NbS as an adaptation measure in OECD countries. National adaptation plans bring together countries' policy priorities and suggested actions as part of the national policy agenda for climate change adaptation, of which water-related risks are a key part. Table 5.1 shows that out of the 35 OECD[4] countries that have national adaptation plans or strategies, 24 directly mention NbS[5,6].

References to NbS range from countries simply stating that they recognise the importance of these approaches as part of climate change adaptation, to the explicit reference of using NbS for addressing specific hazards. For example, when looking at the national adaptation plans for Japan and Poland, NbS are stated as being valuable approaches that will become increasingly important due to intensifying climate impacts. In the cases of Australia, Canada, Denmark and Norway, specific NbS are referenced as being important approaches that can complement grey infrastructure in certain sectors, with wetlands and urban greening being two examples. Australia stands out in that the plan mentions the suitability of NbS in the areas of coastal, river as well as urban flooding. In the absence of coasts, Hungary is another example where NbS feature prominently in their national adaptation policy framework. Their use is suggested in the areas of riverine and urban flooding as well as to address drought risk.

Despite the fact that the majority of OECD countries have incorporated the concept of NbS into their national adaptation plans, very few suggest more concretely how NbS should be features in implementation. Only six countries make such references to concrete implementation measures, such as the creation of policies mandating the use of green drainage systems, the monitoring of ecosystem services, and proposing policies requiring the use of natural flood prevention mechanisms. No national adaptation policies contain quantitative and measurable targets relating to NbS deployment and performance.

Apart from national adaptation policies, a 2019 OECD survey on the implementation of the OECD Recommendation on Water suggests that NbS feature quite prominently in water management strategies, and many countries seem to be using NbS to address water quality, quantity (i.e. water scarcity) as well as flood risk management issues. The survey found that 23 out of 27 country respondents include NbS in their water management strategies (OECD, 2020[85]). Seventeen countries put forward that NbS are being used for water quantity management, while 18 countries use NbS for flood risk management. Examples of other uses included managing storm water and rainwater harvesting (Figure 5.1 – page 18).

In addition to national adaptation plans, there are of course many other policy instruments that aim at facilitating their use in different policy areas such as water management and land-use planning. For example, the EU Floods Directive (2007) promotes nature and risk-based adaptation planning opposed to technological hazard mitigation. A 2019 study found that this directive has

TABLE 5.1. **NbS in National Adaptation Plans or Strategies**

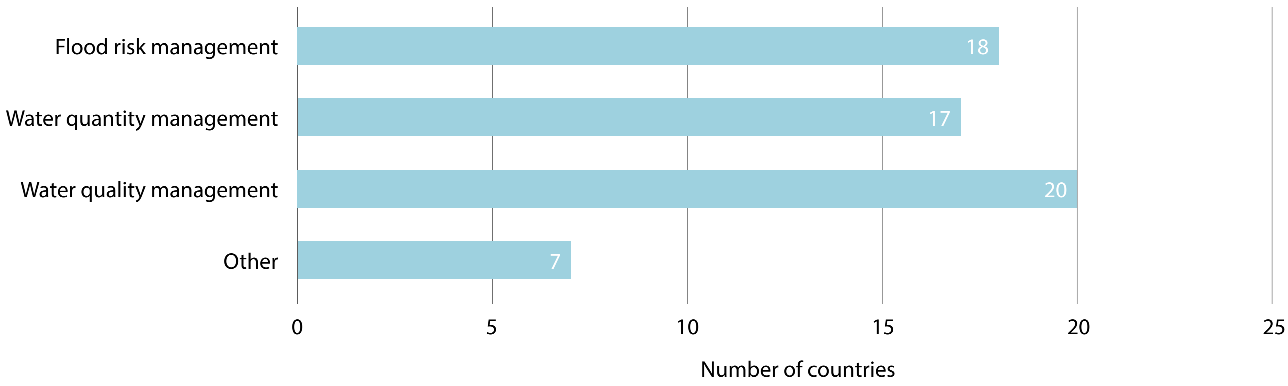
OECD Country*	Reference to NbS in national adaptation plans/ strategies					Clear link to an implementation strategy?
	Coastal hazards	River flooding	Urban flooding	Drought	Other	
Australia	●	●	●			
Austria		●	●			●
Belgium			●			
Canada*		●	●			
Chile	●		●		●	●
Colombia	●			●	●	
Czech Republic				●	●	
Denmark	●		●		●	
Estonia						
Finland						
France			●		●	
Germany					●	
Greece						
Hungary		●	●	●		
Ireland			●	●		
Israel						
Italy						
Japan					●	
Latvia		●			●	
Lithuania						
Luxembourg						
Mexico	●	●				
Netherlands		●	●			●
Norway		●	●			●
Poland	●	●	●			●
Portugal						
Slovak Republic		●		●		
Slovenia						
South Korea						
Spain	●					
Sweden			●			●
Switzerland				●		
Turkey			●		●	
United Kingdom			●			●
United States**	●		●			●

* Iceland and New Zealand excluded, as they do not have a national adaptation plan. New Zealand, however, has a central government adaptation programme, as well as an adaptation technical working group.

** The United States Environmental Protection Agency created a policy document in 2014 for the purpose of providing policy makers with adaptation implementation strategies.

Source: Sources listed in Annex B

FIGURE 5.1. **Domains where NbS are being applied in OECD countries**



Note: Responses to the question: "In which domains are the use of ecosystem-based approaches suggested?" Multiple responses were possible.

Source: 2019 survey on the implementation of the OECD Council Recommendation on Water; 27 country responses received

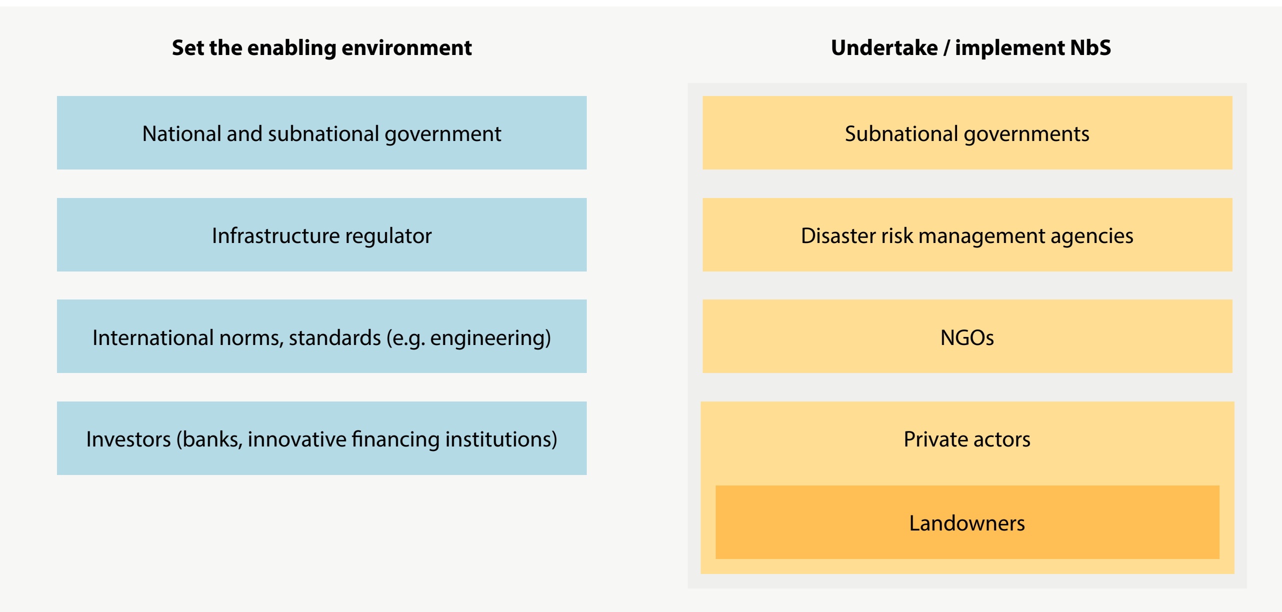
prompted 26 Member States to include NbS (referred to as Natural Water Retention Measures, NWRM) in some or all of their flood risk management plans. However, the degree to which countries included them varies significantly (Trémolet S. et al, 2019[6]).

Some countries have introduced financial or regulatory incentives at national level to encourage the use of NbS (see Box 5.1). These include direct financial support for pilot projects and the associated increase in technical capacity (such as seen in the European Union, the United Kingdom, and Canada), or encouraging the use of NbS through regulatory change (United Kingdom, United States, and Norway).

While national public agencies have an important role in designing a conducive environment for the use of NbS, Fig. 5.2 shows that are many different types of actors, public and private, involved in implementing them.

Overall, while the use of NbS are highlighted and encouraged in policy in a few countries, many countries acknowledge that there is significant room for improving their actual use. In the 2019 OECD Survey on the Implementation of the OECD Water Recommendation, only 2 respondents found current implementation of NbS to be adequate, whereas 17 saw room for improvement.

FIGURE 5.2. **The role of different actors in NbS deployment**



While the use of NbS is highlighted and encouraged in policy in a few countries, many countries acknowledge that there is significant room for improving their actual use.

BOX 5.1. **Instruments in OECD countries to encourage the use of NbS at national level**

- In **Canada**, both nature-based and grey infrastructure projects are eligible for funding as structural prevention measures under the 1.6 billion CAD Disaster Mitigation and Adaptation Fund, aimed at helping communities manage risks from floods, droughts and other hazards.

- In **Europe**, the EU Horizon 2020 framework programme for research and innovation, has allocated approximately EUR 185 million to research and pilot applications of NbS between 2014 and 2020.

- In **Norway**, central government planning guidelines for adaptation encourage municipalities and counties to use NbS in their land-use and general planning processes. In 2018, a requirement was introduced that municipalities first consider the conservation, restoration or establishment of NbS (such as existing wetlands or new green roofs, etc.), and if other measures are chosen, municipalities need to justify why an NbS was not. At present, the national government is working on providing more detailed guidance for municipalities' and regional authorities' on how to fulfil the new planning guidelines.

- In the **United Kingdom**, the "National Planning Policy Framework" requires municipalities to implement natural drainage systems in residential developments with ten or more homes, as well as in major commercial and mixed use developments. In addition, the Department for Environment, Food and Rural Affairs (Defra) has invested GBP 15 million into natural flood management schemes, while environmental agencies across the three countries have worked with the Environment Agency (EA) to publish the Working with Natural Processes to Reduce Flood Risk directory.

- In the **United States**, the Environmental Protection Agency (EPA) has developed technical assistance for local governments on how to design, promote and implement NbS for effective stormwater management. In addition, The US Army Corps of Engineers has streamlined the permitting process for living shorelines in an effort to incentivise these measures and correct the comparative advantage held by hard infrastructure projects in terms of shorter time frames to receive permits

Sources: AECOM (2018), *Three ways to encourage more natural flood management*, https://www.aecom.com/without-limits/article/three-ways-to-encourage-more-natural-flood-management/; European Parliament (2017), Nature-based solutions: Concept, opportunities and challenges, http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2017)608796; GOV.NO (2018), Statlige planretningslinjer for klima, https://lovdata.no/dokument/SF/forskrift/2018-09-28-1469; United States Environmental Protection Agency (2018), Stormwater Management and Green Infrastructure Research, https://www.epa.gov/water-research/stormwater-management-and-green-infrastructure-research.

6 A policy evaluation framework to support an enabling environment for NbS

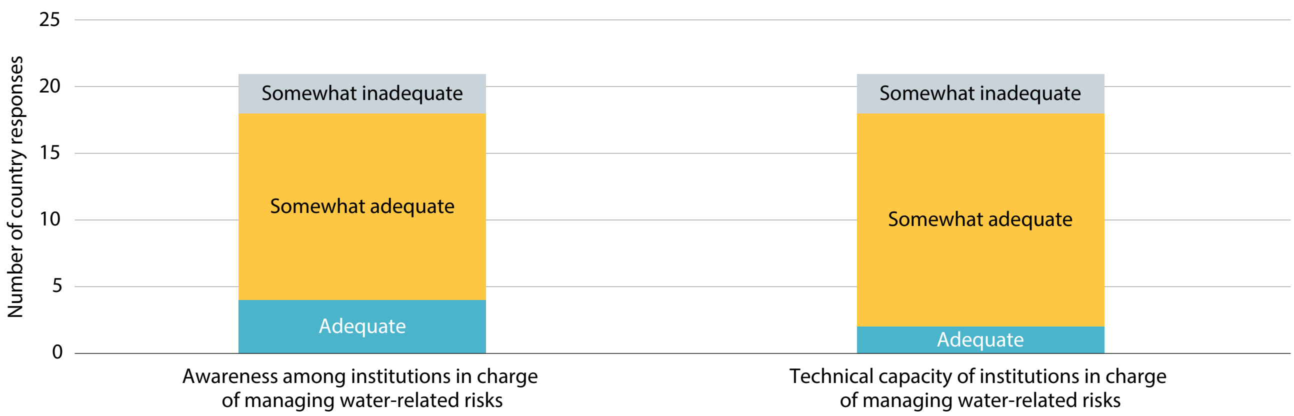
The discussion of the integration of NbS in national policy frameworks to date brings to light that ambition for NbS does not match practice. Although there is growing recognition of the use of NbS as part of the policy measures employed to address water-related risks, existing policy evidence and feedback from country surveys suggest that their actual implementation is lagging far behind the use of traditional grey infrastructure measures.

Figure 6.1 suggests that in addition to national policy frameworks, a lack of awareness and technical capacity among those public and private actors in charge of using them could act as barriers. This is corroborated by (Kapos et al., 2019[4]) who suggest that many actors may have limited awareness of either the importance of ecosystems to societal resilience or the potential of NbS to help meet risk management objectives. (Sarabi et al., 2019[86]) go a step further and suggest that there are entrenched attitudes and perceptions among many that traditional grey solutions are the only practical and reliable option for managing water-related risks. In regard to technical capacity, (Kabisch et al., 2016[25]) suggest that NbS are viewed as too difficult for implementation or not being considered at all. Finally, limited access to appropriate finance is a major barrier preventing the delivery of NbS (Trémolet S. et al, 2019[6]).

For NbS to become more widely used alternatives to other solutions that address water-related risks, a better understanding is needed of to what extent these unique characterises impede their uptake in different country contexts, and how this can be overcome. In the following, a policy evaluation framework is suggested, which can help assess to what extent countries' enabling environments can be improved to strengthen the use of NbS.

The policy framework addresses two fundamental issues: First, how can NbS, given their characteristics, "fit" into existing planning and investment decision-making processes? Second, identify where and how these processes need to be adjusted to remove distortions so NbS can be considered on an equal playing field to other options. This framework will be applied to subsequent case studies, with the goal of going beyond an understanding of barriers to NbS and provide guidance on how these barriers could be systematically overcome to insure coherent articulation of what NbS can achieve and how they can be deployed at scale.

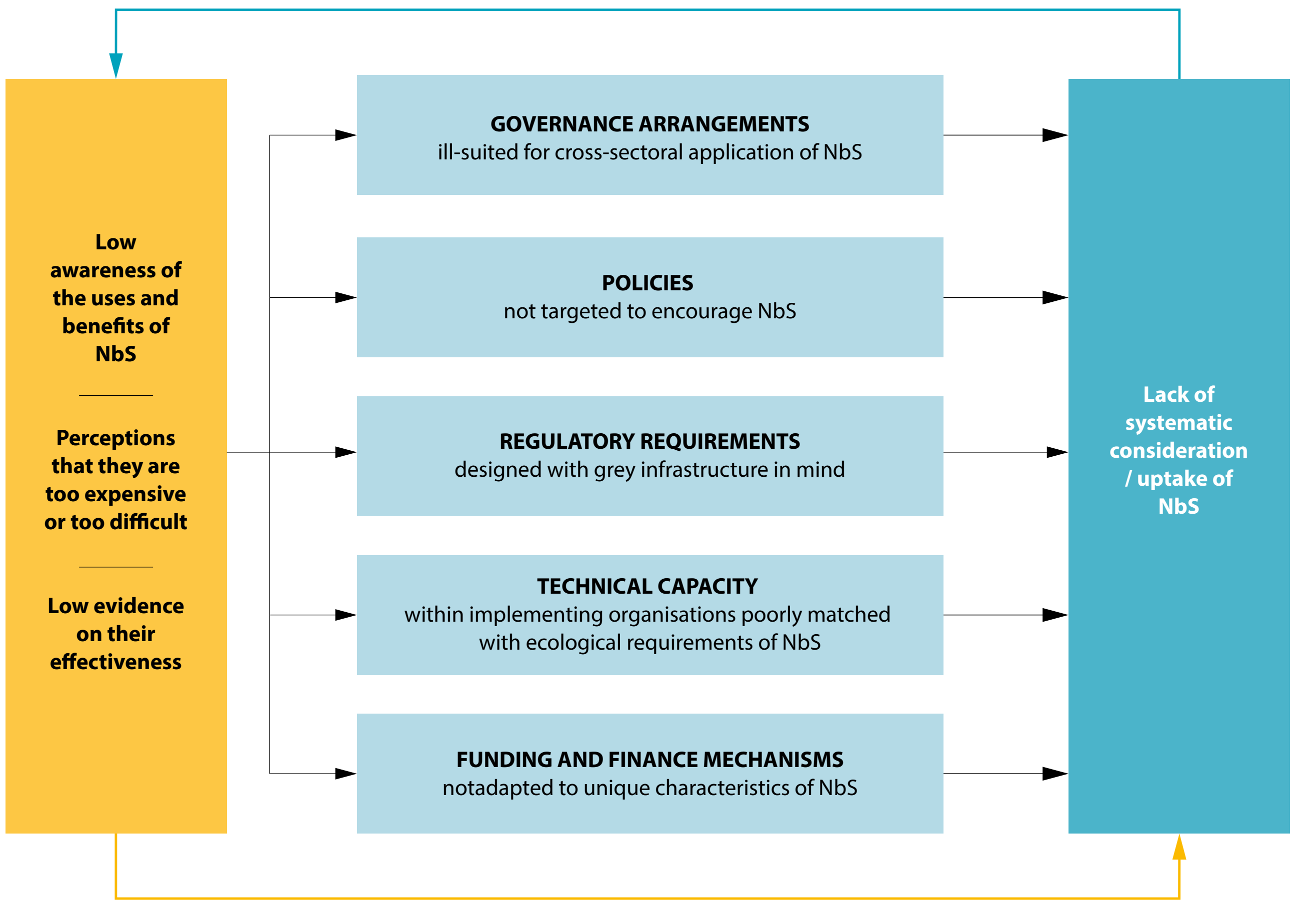
FIGURE 6.1. **The role of different actors in NbS deployment**



Note: Response to the question: "How adequate are the following features in relation to eco-system-based approaches to water management in your country/basin?'"; multiple responses were possible; no respondents selected "inadequate".

Source: 2019 survey on the implementation of the OECD Council Recommendation on Water; 27 responses received, including 26 Adherents

FIGURE 6.2. **Policy evaluation framework for NbS**



CONDUCIVE GOVERANCE ARRANGEMENTS

Considering the number of policy areas and public authorities potentially involved in the deployment and financing of NbS, good governance is an essential enabling factor. The impacts of an NbS are spread through a system and influenced by decisions made by individual sectors. For example, the introduction of increased green space to manage urban flooding can reduce operational costs for the housing sector (through a reduction in energy use for cooling), and offset the negative environmental impacts of the transport sector (through a reduction in road runoff pollution). Different agencies are often not set up to provide the level of coordination needed for NbS as they tend to operate in sectoral silos, with their own vision, legal frameworks, planning documents, resources and procedures.

Key policy elements to be evaluated:

- *Responsibilities for different aspects of NbS planning, implementation and maintenance*
- *Coordination mechanisms (horizontal and vertical)*

SUPPORTIVE POLICIES

Clear mandates from the highest policy level have the potential to accelerate NbS uptake. Different sectoral policies can additionally influence the attractiveness of NbS. Policies relating to spatial planning and land use, biodiversity conservation, agriculture, water management, and health are key to the feasibility and appeal of implementing NbS, however the use of NbS are rarely explicitly encouraged in these policies (Wingfield et al., 2019[73]). Worse, there may be directly conflicting interests between NbS and other policy objectives. For instance, many NbS are land consuming and there can be strong competition for land, particularly in urban or peri-urban areas.

Key policy elements to be evaluated:

- *Clear mandate and support for NbS*
- *Coherence between sectoral policies, and mechanisms to address trade-offs*
- *Encouragement of NbS within infrastructure planning processes*

- *Methodologies in place for measuring benefits*
- *Inventory of existing natural capital/assets*

APPROPRIATE REGULATORY ENVIRONMENT

The regulatory environments have a powerful influence on the feasibility of using NbS for adaptation to water risk. In general, the prevailing regulations and technical standards have been developed from grey infrastructures as the main, or only available, option to address given challenges, which can create bias towards the exclusive use of grey infrastructure.

Key policy elements to be evaluated:

- *Land-use regulation and zoning*
- *Permitting*
- *Safety and performance codes and standards*
- *Procurement policies*
- *Land rights*
- *Environmental protection regulation*

TECHNICAL CAPACITY

Gaps in technical capacity can impede the design and wider implementation of NbS. As for other risk management approaches, the use of NbS rely on an understanding of risk drivers, the processes and mechanisms by which an approach can be expected to work, the limitations to its effectiveness, and measures that can enhance that effectiveness and provide co-benefits. The skills and knowledge needed to identify and implement NbS are often not in the training of the professionals often involved in designing and implementing risk management interventions, such as engineers.

Key policy elements to be evaluated:

- *Partnerships and information sharing*
- *Integration of NbS training in civil engineering and urban planning curricula*
- *Training and education*

ACCESS TO FINANCE

Limited access to appropriate finance is cited as a major barrier preventing the delivery of NbS. Increased uptake of NbS depends on rerouting or unlocking new funds to support them. NbS currently lack appropriate financing instruments and standardised financing models, which make them particularly unattractive for potential financiers. One major challenge is to associate NbS benefits with private values, rather than public goods, which can repay those who contribute to the funding schemes. This can be especially challenging considering many of the potential co-benefits of NbS are not traded in the market. Many investors may consider NbS to be high risk and low reward, and may default to better known and tested solutions, in the absence of robust NbS performance data.

Key policy elements to be evaluated:

- *Availability of targeted incentives*
- *Ability to capture revenue streams*
- *Financing requirements*
- *Distribution of liabilities*

7 Conclusions

This paper frames the key issues around the use of NbS in general and for water-related risks in particular. It highlights that while countries place increasing emphasis on the benefits of NbS in high-level policy frameworks, implementation is not keeping pace with ambition. The paper proposes a policy evaluation framework that helps identifying good practices as well as the persisting bottlenecks in the use of NbS for reducing exposure to water-related risks. Ultimately, this can foster and facilitate the implementation of NbS.

ENDNOTES

1. For a broader review on the origin of the concept of NbS, please refer to: Nesshöver C., Assmuth T., Irvine K.N., Rusch G.M., Waylen K.A., Delbaere B., Haase D., Jones-Walters L., Keune H., Kovacs E., Krauze K., Külvik M., Rey F., van Dijk J., Vistad O.I., Wilkinson M.E., Wittmer H. (2017) The science, policy and practice of nature-based solutions: An interdisciplinary perspective. Science of the Total Environment 579: 1215–1227.
2. This paper uses the CBD definition of biodiversity, which is "the variability among living organisms fromall sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems."
3. Grey infrastructure is defined as man-made, engineered infrastructure
4. Remarks by the OECD Secretary General at the Nature-Based Solutions Momentum High-level Event can be found here: https://www.oecd.org/about/secretary-general/nature-based-solutions-momentum-high-level-event-september-2019.htm
5. Source: comments from US delegation on scoping note circulated at 13th WPWBE
6. 35 out of 37 OECD countries
7. The absence of any reference to NbS in the national adaptation policies does not mean NbS are not included and used to address water-related risks in those countries.
8. Across areas of water quality and quantity management

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Annex A. National Adaptation Plans/ Strategies in OECD Countries

TABLE AA.1. **National Adaptation Plans/ Strategies in OECD Countries**

Country	Name	Year	Link
Australia	National Climate Resilience and Adaptation Strategy	2015	https://www.environment.gov.au/system/files/resources/3b44e21e-2a78-4809-87c7-a1386e350c29/files/national-climate-resilience-and-adaptation-strategy.pdf
Austria	The Austrian Strategy for Adaptation to Climate Change	2012	https://www4.unfccc.int/sites/NAPC/Documents%20NAP/The%20Austrian%20Strategy%20for%20Adaptation%20to%20Climate%20Change.pdf
Belgium	Belgian National Adaptation Plan	2017	https://www.cnc-nkc.be/sites/default/files/report/file/nap_en.pdf
Canada	Pan-Canadian Framework on Clean Growth and Climate Change	2016	http://publications.gc.ca/site/eng/9.828774/publication.html
Chile	Plan de Acción Nacional de Cambio Climático 2017-2022 (PANCC-II)	2017	http://portal.mma.gob.cl/wp-content/uploads/2017/07/plan_nacional_climatico_2017_2.pdf
Colombia	Plan Nacional de Adaptación al Cambio Climático	2016	https://www.preventionweb.net/files/58251_colombianapspanish.pdf
Czech Republic	Strategy on Adaptation to Climate Change in the Czech Republic	2015	https://www.mzp.cz/C125750E003B698B/en/strategy_adaptation_climate_change/$FILE/OEOK_Adaptation_strategy_20171003.pdf
Denmark	Danish Strategy for Adaptation to a Changing Climate	2008	http://en.klimatilpasning.dk/media/5322/klimatilpasningsstrategi_uk_web.pdf
Estonia	Climate Change Adaptation Development Plan until 2030	2017	http://www.envir.ee/sites/default/files/national_adaptation_strategy.pdf
Finland	Finland's National Climate Change Adaptation Plan 2022	2014	http://mmm.fi/documents/1410837/5120838/MMM-_193086-v1-Finland_s_National_climate_Change_Adaptation_Plan_2022.pdf/582041ee-3518-4a63-bf60-7133aed95a9c
France	Nouveau plan national d'adaptation au changement climatique : Premières pistes	2017	https://www.ecologique-solidaire.gouv.fr/nouveau-plan-national-dadaptation-au-changement-climatique-premieres-pistes
Germany	German Strategy for Adaptation to Climate Change	2008	https://www.preventionweb.net/files/27772_dasgesamtenbf1-63.pdf
Greece	National Strategy for Adaptation to Climate Change	2016	https://www.preventionweb.net/files/61765_06.04.2016.pdf
Hungary	National Adaptation Strategy (as part of the 2nd National Climate Change Strategy 2018-2030 with an outlook until 2050 - NCCS-2	2018	http://doc.hjegy.mhk.hu/20184130000023_1.PDF
Ireland	National Adaptation Framework	2018	https://www.dccae.gov.ie/documents/National%20Adaptation%20Framework.pdf
Israel	Adaptation to Climate Change in Israel	2014	http://www.sviva.gov.il/InfoServices/ReservoirInfo/DocLib2/Publications/P0701-P0800/P0739.pdf
Italy	National Adaptation Plan	2016	http://www.minambiente.it/sites/default/files/archivio/allegati/clima/strategia_adattamentoCC.pdf
Japan	National Plan for Adaptation to the Impacts of Climate Change	2015	http://www.env.go.jp/en/focus/docs/files/20151127-101.pdf
Korea	2nd National Climate Change Adaptation Strategy	2015	https://www.preventionweb.net/files/58461_korearepofsummarysecondnationalclim.pdf
Latvia	Latvian National Plan for Adaptation to Climate Change until 2030	2019	https://likumi.lv/ta/id/308330-par-latvijas-pielagosanas-klimata-parmainam-planu-laika-posmam-lidz-2030-gadam
Lithuania	The Strategy for National Climate Change Management Policy for 2013 - 2050	2012	https://www.e-tar.lt/portal/lt/legalAct/TAR.F1333EAD263B

Country	Name	Year	Link
Luxembourg	Strategie und Aktionsplan für die Anpassung an den Klimawandel in Luxemburg (2018-2023)	2018	https://environnement.public.lu/dam-assets/documents/klima_an_energie/Anpassungsstrategie-Klimawandel-Clean.pdf
Mexico	Mexico's Climate Change Mid-Century Strategy	2016	https://www.gob.mx/inecc/documentos/mexico-s-climate-change-mid-century-strategy
Netherlands	Adapting with Ambition: National Climate Adaptation Strategy	2016	https://ruimtelijkeadaptatie.nl/overheden/nas/
Norway	National Adaptation Strategy (White paper)	2013	https://www.regjeringen.no/contentassets/e5e7872303544ae38bdbdc82aa0446d8/en-gb/pdfs/stm201220130033000engpdfs.pdf
Poland	Polish National Strategy for Adaptation to Climate Change (SPA 2020)	2013	https://klimada.mos.gov.pl/wp-content/uploads/2014/12/ENG_SPA2020_final.pdf
Portugal	National Adaptation Strategy	2015	https://dre.pt/application/file/a/69906414
Slovak Republic	Climate Change Adaptation Strategy of the Slovak Republic	2018	https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/strategia-adaptacie-sr-zmenu-klimy-aktualizacia.pdf
Slovenia	Strategic Framework for Climate Change Adaptation	2016	https://www.preventionweb.net/files/61770_sozp.pdf
Spain	National Adaptation Plan	2008	https://www.preventionweb.net/files/58384_thespanishnationalclimatechangeadap.pdf
Sweden	Regeringens proposition 2017/18:163 Nationell strategi för klimatanpassning	2017	https://www.regeringen.se/494483/contentassets/8c1f4fe980ec4fcb8448251acde6bd08/171816300_webb.pdf
Switzerland	Adaptation to climate change in Switzerland	2012	https://www.bafu.admin.ch/bafu/en/home/topics/climate/publications-studies/publications/adaptation-climate-change-switzerland-2012.html
Turkey	Turkey's National Adaptation Strategy and Action Plan	2012	http://www.dsi.gov.tr/docs/iklim-degisikligi/turkeys-national-climate-change-adaptation-strategy-and-action-plan.pdf?sfvrsn=2
United Kingdom	The National Adaptation Programme and the third strategy for climate adaptation reporting	2018	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727252/national-adaptation-programme-2018.pdf
United States	U.S. Environmental Protection Agency Climate Change Adaptation Plan	2014	https://www.epa.gov/sites/production/files/2015-08/documents/adaptationplans2014_508.pdf

Note: Iceland and New Zealand excluded, as they do not have a national adaptation plan. New Zealand, however, has a central government adaptation programme, as well as an adaptation technical working group.

Nature-based solutions for adapting to water-related climate risks

Healthy ecosystems, and their associated services, can provide effective natural protection against water-related climate risks. Nature-based solutions (NbS) have recently gained momentum in international policy discussions due to their potential to foster synergies between ecosystem health and human wellbeing, while also offering economic benefits. This paper provides an overview of the use of NbS to date in OECD countries and finds that in most cases ambition for NbS does not match practice. Focusing on the application of NbS for addressing climate-related flood and drought risks, this paper explores why prevailing decision making frameworks may fail to adequately consider NbS. It sets out a policy evaluation framework that supports the identification of, and proposed ways to address constraints on the use of NbS to address water-related climate risks.

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